IoT based Product Recommendation System for Shopkeepers using Machine Learning

Sridharan C
Associate Professor,
Department of Computer Science and Engineering,
Thiagarajar College of Engineering
cscse@tce.edu

Nitin Vinayak S
Department of Computer Science and Engineering,
Thiagarajar College of Engineering
nitin@student.tce.edu

Rajarajesvarri G
Department of Computer Science and Engineering,
Thiagarajar College of Engineering
rajarajesvarri@student.tce.edu

Abstract - **One of the biggest challenges faced by shopkeepers today is the need for more access to customer data and insights into their preferences and behavior. As a result, it can be difficult for shopkeepers to make informed decisions regarding restocking their inventory. In order to address this issue, a Product Recommendation System for supermarkets and shopkeepers has been developed that utilizes a smart trolley equipped with RFID (Radio Frequency Identification) technology based on the Internet of Things (IoT) to track items that customers place in their carts during shopping and process those items using a machine learning model to recommend products to the shopkeepers. This system not only automatically records the items purchased by the customers but also provides recommendations to shopkeepers based on data collected from customer shopping behaviours. By analyzing this data with machine learning algorithms, shopkeepers receive personalized restocking recommendations to optimize their stocks based on the most sold products and recommend such products to the shopkeepers so that their revenue increases.**

Keywords - **Recommendation System, RFID, IoT, Smart Trolley**

I. INTRODUCTION

Currently, most supermarkets and department stores use a simple barcode system that requires store staff to scan the barcode with a laser scanner at specific locations within the store. This system is inefficient and time-consuming, as the barcode scanner requires the product to be in the line of sight and scanned one at a time, making it tedious for both staff and customers. Moreover, the COVID-19 outbreak has made it increasingly necessary to reduce crowds and speed up essential service processes, and the barcode system cannot provide adequate support during this crisis. The proposed solution is an IoT-based Smart cart system and Radio-frequency identification (RFID) that eliminates the need for long queues, reduces manpower, and makes the management system much more efficient for customers. The device will be installed on the shopping cart, allowing customers to scan their products themselves, generate a bill, make the required payment via a linked payment gateway, and provide recommendations to the supermarket owners and shopkeepers based on the number of units sold. The scanned product details will be updated on the retailer's database, which then will be processed using a machine learning model, enabling sales analytics to maximize their profit. RFID tags can be scanned at a long range and integrated with security to provide an extra anti-theft measure. Incorporating all these components is necessary to provide a complete experience while still increasing the store's efficiency and security.

The proposed design is more functionally efficient than existing models in the industry. RFID readers are not widely used, and self-checkout services use barcodes as the ID instead. However, barcodes do not offer the same level of security as RFID and lack additional features such as real-time product tracking and inventory management. The RFID scanners used in shops are primarily handled by cashiers, and they are not designed for specialized product recommendations to shopkeepers so that they can stock their most sold products thereby they can increase their revenues. Artificial Intelligence Recommendation Systems for shopping that exist are not real-time and do not have a system in place to handle both shopping and recommendations for shopkeepers simultaneously. Therefore, while individual technologies exist in the domain, no product provides a comprehensive experience for both the shopkeeper and the user.

II. LITERATURE SURVEY

The use of RFID technology is rapidly increasing, and its application in shopping carts is expected to enhance the customer experience and streamline the billing process. Research has shown that combining RFID and Zigbee technology with a centralized billing system application can automate the billing process in malls. This system al-

lows customers to pay for their purchases using credit/debit cards, with the bill stored on a local database and a log of the purchases maintained for future analysis. Peripheral devices such as Zigbee, LCD, and a microcontroller are used to interface with the system. Smart Billing systems enable customers to add items to their cart and upload them to an online application, which can be paid for using online wallets. Each customer is provided with a membership card, which is swiped on the sensor in the cart to upload the purchased items to their account on the application. Each trolley is equipped with an RFID scanner and a Zigbee module, which upload the user data to the system.

In some other projects, a Raspberry Pi module is used to enable users to upload their data to an online platform, allowing them to pay for their items using an online wallet and keep track of their cart's contents. However, the existing systems do not provide user recommendations for other similar products in the store based on their shopping history, and there is no online database to track and log all user transactions and recommend any products to the store owners based on the purchasing history of the customers. The products are not categorised to predict sales trends. When Zigbee and microcontrollers are used, the data is stored locally in the shop instead of on the cloud, preventing users from connecting their mobile devices to the system.

Most of the proposed systems only allow users to access their bill via the LCD screen, making mobile wallet and cash payments difficult and increasing the risk of theft and tampering. Apart from this, all the previously proposed solutions focus only on the customer experience, the billing gateway, and the automatic shopping cart and not on the problems faced by the shopkeepers and the supermarket owners. From our literature survey, we have realized that while these ideas are feasible and easy to implement, they may not be secure and may not provide a complete user experience and better shopping experience for supermarket owners and shopkeepers. This drawback can be overcome by uploading the data collected by the RFID to the database and then processing the data using a machine learning model, thereby allowing us to manage many users and securely store the data with multiple backups and recommend the saleable products to be stored in the shops, supermarkets and to meet the needs of the customers for better shopping experience.

III. OBJECTIVE

The primary objective of the project is to provide shopkeepers with product recommendations based on the number of units sold and the item popularity. Initially we integrate RFID technology into shopping trolleys in order to achieve automated billing of items in the shopping trolley. The automation of billing eliminates the need for customers to wait in a queue in supermarkets. This will improve the customer experience. Every time the customer adds/removes a product into/from the shopping trolley, the RFID tag will be scanned and the user's cart that will be active in the server will be updated of the customer's actions. All the sales data will be stored in the database from where it will be fed as input to the recommendation system. The recommendation system is built to recommend the shopkeepers on a particular product and all of it's related products based on the availability of the current stocks and arrival of new stocks. The machine learning model will analyze the popular products in the shop and recommend the shopkeepers with similar products for the shopkeepers to restock that ought to bring in more customers. This shall also enable the shopkeepers to manage the stocks better by collecting the necessary information such as the goods sold, available goods and to recommend the frequently sold products and their related products. This IoT based recommendation system allows for the shopkeepers to implement marketing strategies, to increase the sales of goods and services and make the business profitable.

IV. HARDWARE AND TECHNOLOGIES USED

- **RFID :** RFID stands for Radio Frequency Identification, which is a technology that uses radio waves to identify and track objects. RFID tags are small electronic devices that can be attached to or embedded in objects, and they contain a unique identifier that can be read by RFID readers using radio waves. RFID scanner can be used to scan the RIFD tags embedded in the items in the shop. This technology is optimal for automation of billing.
    - **Passive RFID :** Passive RFID tags are electronic tags that do not have a built-in power source, but instead rely on radio waves from an RFID reader to power them up and enable communication. Passive RFID tags are commonly used for applications such as inventory management, asset tracking, and supply chain management.
- **ESP-32 :** ESP-32 is a modern technology that is low-cost, high-performance system-on-chip (SoC), low-power that is widely used for building Internet of Things (IoT) devices. It is based on the Xtensa LX6 CPU, which is a dual-core 32-bit processor. It is said to operate at up to 240 MHz. The ESP-32 SoC includes Wi-Fi and Bluetooth connectivity, as well as a wide range of peripheral interfaces, such as SPI, I2C, UART, and ADC. It also has built-in support for various protocols, including HTTP, MQTT, and CoAP, making it easy to connect to the Internet and communicate with other devices. The ESP-32 is popular for a wide range of IoT applications, including smart home devices, industrial automation, and wearables.
- **Firebase :** Firebase is a cloud-based mobile and web application development platform. It provides a wide range of backend services and tools to help developers build and scale their applications quickly and easily. Firebase offers many features, including real-time database, authentication, cloud storage, cloud messaging, and hosting. The real-time database is a NoSQL database that enables developers to store and sync data in real-time across multiple clients. Authentication allows developers to manage user authentication, while cloud

storage enables them to store and share user-generated content, such as images and videos. Cloud messaging provides a reliable and scalable way to deliver messages to and from mobile and web applications, and hosting offers a simple and fast way to deploy web applications. Firebase also offers machine learning services, such as ML Kit, which is a mobile SDK that makes it easy to integrate machine learning features into mobile apps, without requiring any knowledge of machine learning. In this project, the data related to the shop's sales are to be stored in a realtime database. Hence Firebase is used to store and retrieve realtime data for feeding into the machine learning model.

- **LCD :** An LCD (Liquid Crystal Display) module is a type of electronic display module that is commonly used in Smart Cart systems. It provides a user-friendly interface that displays relevant information such as the price, name, and quantity of the products being scanned by the RFID TAG. In a Smart Cart system, the LCD module is usually connected to a microcontroller that processes the data from the RFID tag and sends the relevant information to the display. The display is typically designed to be easy to read and operate, with clear and bright characters and symbols.

- **Arduino Uno :** Arduino Uno is a microcontroller board. It is based on the ATmega328P. It is widely used in various electronic projects, including robotics, automation (especially home automation), and Internet of Things applications. There are 14 digital input/output pins in an Arduino Uno board. Out of 14 pins, 6 can be used as PWM outputs and 6 as analog inputs. A 16 MHz quartz crystal, a power jack, a USB connection, and an ICSP header are also parts of the Arduino Uno board. The board can be powered with an external power supply or via the USB connection.

- **Machine Learning :** Machine learning is a type of artificial intelligence (AI) that enables computers to learn and make predictions or decisions based on patterns in data, without being explicitly programmed to do so. In machine learning, algorithms use statistical techniques to learn from data and improve their performance over time. For this project the ideal type of machine learning algorithm is observed to be Collaborative Filtering.

- **Flask :** Flask is a web framework and it is widely used in building web applications using the Python. Flask is built on top of the WSGI toolkit and provides a simple and efficient way to handle HTTP requests and responses. It also provides many features, such as URL routing, template rendering, and form handling. Flask also has built-in support for secure cookies, sessions, and message flashing, making it easy to manage user authentication and data persistence. One of the key features of Flask is its modular design, which allows developers to add or remove components as needed, making it a highly customisable framework. Additionally, Flask integrates well with other Python libraries, such as SQLAlchemy for database access, Jinja2 for template rendering, and WTForms for form handling. Flask is used to display the output given by the machine learning model (i.e. Product Recommendation System) in a website that the shopkeeper can refer to.

- Other minor components used in the construction of the RFID Scanner for the shopping trolley are i2C Module, LED Indicators, Buttons and Buzzers.

V. IMPLEMENTATION

- **User Flow :**

A shopping trolley is implemented in this section. This shopping trolley has been equipped with an RFID Scanner. This RFID Scanner is built with an RC522 RFID Reader, ESP-32 Chip, LED Indicator, LCD Display to display the required to the customer and a battery module that powers the whole system. The RFID Tags are attached to the items in the shop. Now when the customer decides to buy some item, they will take the item and place it in their shopping trolley. This will trigger the RFID Reader to read the RFID tag attached to the item. The LCD display attached to the shopping trolley will display the updated number of items in the trolley. The item details and the price will be sent to the ESP-32 where the customer's bill shall be updated in the server. This is made possible because ESP-32 is equipped with a built-in Wi-Fi and dual mode bluetooth. The whole process is shown in Figure 1.

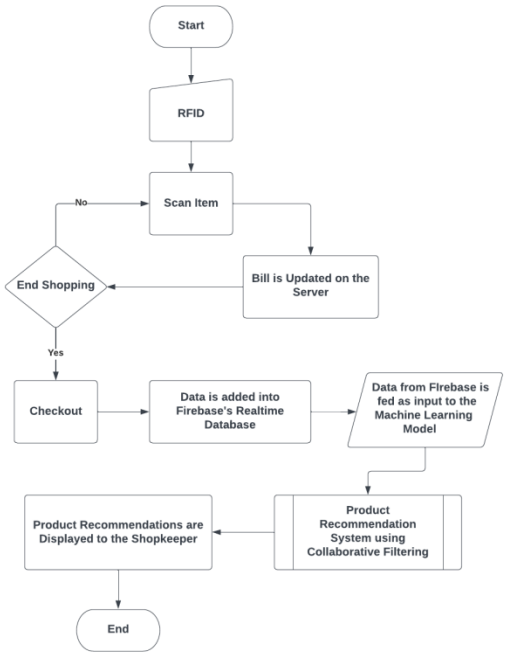

Figure 1 : Working of the System

After the customer is done with their shopping, their bill is immediately generated. The customer then just proceeds with the checkout, with no further hassle. This system later provides the shopkeepers with product recommendations. This recommendation works by the machine learning model receiving the sales and stocks data as input. Collabora-

tive Filtering machine learning algorithm is used to build this product recommendation system. After the processing, the shopkeeper is presented with a list of products that are recommended for them to restock in their stock. (i.e. The shopkeeper has access to a list of items that are the most popular in their shop. Also they are shown a variety of similar products that the customers might be interested in.) This product recommendations can be viewed by the shopkeepers in a website dedicated to it.

- **Security :**

RFID technology can help retailers prevent theft and loss of products. If an item with an RFID tag is removed from the store without being purchased, the system can automatically detect it and trigger an alarm.

Hence the use of RFID technology in security bars can help reduce losses due to shoplifting and improve security in the store.

- **Collaborative Filtering Recommendation System :**

Collaborative filtering is used for building recommendation systems for e-commerce websites and other online marketplaces. In this context, collaborative filtering is used to make product recommendations to the shopkeepers based on the sales and item popularity.

To implement collaborative filtering for product recommendations, the first step is to gather data about user behaviour. This can include information about items that users have purchased, viewed, rated, or added to their shopping carts. Once this data has been collected, the next step is to identify patterns and similarities between users based on their behaviour.

To train our product recommendation system, we use a dataset consisting of several items purchased by customers in a shop. The dataset used to train the machine learning model is from various supermarkets which consists of 18383 units sold. The dataset consists of the following parameters: Order ID, Product Name, Quantity Sold, Price of the item, Order Date and the Purchase Address. With this data the system will be able to identify the popular items in the shop, by comparing the sales of the items with the initial stock of the items. We use the item-based approach of collaborative filtering so that we can recommend products to the shopkeepers. This approach will deal with the identification of items that are similar to the items that are identified to be popular in the particular shop. These identified items are then recommended to the shopkeepers. The similar products are identified with the use of K-Means Clustering. By using K-Means Clustering the system shall be able to figure out the correlation between two products. Also it will be able to detect communities of products that occur together. Considering two products A and B as example, suppose product A has seen a sales of 4000 units and product B has sold about 1400 units, then the popularity of those products can be combined with the help of the product recommendation system and can later be made to suggest some alternatives to the shopkeeper.

- **Application Interface :**

The shopping trolley that the customer will use to hold their items to be purchased will be fitted with a RFID scanner system that will scan the RFID tag of the item that the customer will put in the trolley. The ESP-32 will input the RFID unique code and sends it to the server where the customer's cart will be updated. The trolley will also be attached with a LCD display that will be connected to the scanning system. This LCD display will display the total number of items in the trolley and will be updated real-time. When the customer finishes their shopping the final bill will be generated after which the customer shall check-out. The items purchased by the customer will be updated in the server. This will then be given as input to the machine learning model. The processing is done and the results (i.e. Product Recommendations for the shopkeeper) will be displayed in the web-application.

In the above process, it was mentioned that the ESP-32 will input the RFID unique code to the server. This unique RFIC code will be assigned to each and every item in the shop for unique identification. This will greatly help in the collaborative clustering product recommendation system generating a list of recommended items for the shopkeeper.

The key highlight of the application interface is the product recommendations that are listed in the web-application that is dedicated to that particular shopkeeper that enables them for a hassle free restocking. The Application Interface is as shown is Figure 3.

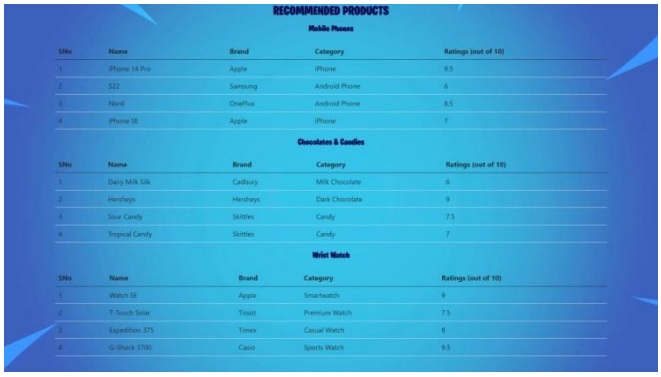

Figure 3 : Application Interface

- **Prototype :**

A prototype of the RFID Scanner system that shall be attached to the shopping trolley has been made using Tinkercad. This can be seen in Figure 4.

The model consists of an ESP-32, EM-18 RFID Reader Module, a Battery Module, an LCD Display (16 x 2), LED indicator and a Button. The presence of ESP-32 eliminates the need for any other external components and extra connections thanks to its built-in internet module. The ESP-32

is powered by the battery module. The use of the LED indicator is it lights up indicating that a new item is added to the shopping trolley by the customer.

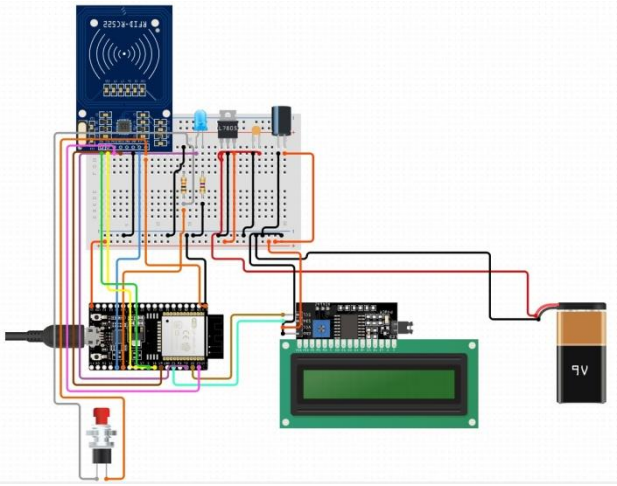

Figure 4 : Prototype Model of the RFID Scanner

All these components are connected accordingly and attached to the shopping trolley. Thus, when a customer puts a new item into the shopping trolley the RFID tag of the item will be automatically read by the RFID scanner attached to the trolley. Also as a security measure, shops shall have RFID scanners in the security bars at the end of the shop in-order to prevent shoplifting. If the customer leaves the shop without proper removal of the RFID tag embedded in the item (RFID tags will not be removed for unpaid items), then the security bar shall raise an alert indicating the same.

VI. FUTURE SCOPE

This proposed system when implemented in a full fledged way in offline stores, then it will eliminate the need for a person at the billing section. Also it will speed up the process of checkout for the customers, resulting in improvement of the customer experience.

The proposed Product Recommendation System for Shopkeepers when implemented, will increase the shop's sales as it tends to recommend products based on the previous sales and item popularity. But before this recommendation system is implemented into the real wold, the machine learning model shall be made more adaptive so that the accuracy and the effectiveness of the model can be highly improved.

In today's world, barcodes are the typical means of billing. But with RFID tags getting cheaper, this might see a significant change in the future. Considering the fact, that RFID scanning and billing also proves to be much secure, it may be the future of standard billing in offline stores.

VII. CONCLUSION

This project has made use of a newer technology, a RFID scanner embedded in shopping trolleys for providing the customers with a hassle-free, shopping experience. This greatly reduces the need for hands-on service in offline stores in terms of billing and security as RFID security bars detect unpaid items. At the same time the shopkeepers are also benefitted with products recommendations for their shop. The shopkeepers can restock heavily on the items recommended by the product recommendation system. This is because of the collaborative clustering converging successfully and providing satisfactory results.

Hence, this project is reliable and benefits the customers and the shopkeepers at the same time.

VIII. REFERENCES

[1] Satheesan, P., Haddela, P. S., & Alosius, J. (2020, December). Product Recommendation System for Supermarket. In 2020 19th IEEE International Conference on Machine Learning and Applications (ICMLA) (pp. 930-935). IEEE.

[2] Gupte, R., Rege, S., Hawa, S., Rao, Y. S., & Sawant, R. (2020, July). Automated Shopping Cart Using RFID with a Collaborative Clustering Driven Recommendation System. In 2020 Second International Conference on Inventive Research in Computing Applications (ICIRCA) (pp. 400-404). IEEE.

[3] Shankar, S. K., Balasubramani, S., Basha, S. A., Ahamed, S. A., & Reddy, N. S. K. (2021, April). Smart trolley for smart shopping with an advance billing system using IoT. In 2021 5th International Conference on Computing Methodologies and Communication (ICCMC) (pp. 390-394). IEEE.

[4] Mekruksavanich, S. (2020, March). Supermarket shopping system using rfid as the iot application. In 2020 Joint International Conference on Digital Arts, Media and Technology with ECTI Northern Section Conference on Electrical, Electronics, Computer and Telecommunications Engineering (ECTI DAMT & NCON) (pp. 83-86). IEEE.

[5] Balamurugan, M., Prabhakar, G., Amsaveni, G., Karthikumar, M., Shifa, J. J., & Sharmila, E. (2022, December). IoT

[6] Hameed, M. A., Al Jadaan, O., & Ramachandram, S.(2012).Collaborative filtering based recommendation system:A survey. International Journal on Computer Science and Engineering, 4(5), 859.

[7] Srifi, M., Oussous, A., Ait Lahcen, A., & Mouline, S. (2020). Recommender systems based on collaborative filtering using review texts—a survey. Information, 11(6), 317.

[8] Suárez, Franz.,Caiza, Germán., & Yoo, Sang Guun (2017).Stock Management System Using RFID and Geolocation Technologies.International Journal of Applied Engineering Research, (12).